PATENT ABSTRACTS OF JAPAN

(11)Publication number : 05-335217
(43)Date of publication of application : 17.12.1993

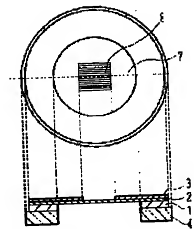
(51)Int.Cl. H01L 21/027
G03F 1/16

(21)Application number : 04-139382
(22)Date of filing : 29.05.1992

(71)Applicant : FUJITSU LTD
(72)Inventor : KAWAKAMI KENICHI

(54) MANUFACTURE OF MASK FOR X-RAY EXPOSURE

(57)Abstract:
PURPOSE: To offset the strain of a mask substantially and to form the mask in a desired shape by a method wherein, when an X-ray absorber film is patterned to a desired mask shape, the strain of the mask which is caused due to a change in the distribution of a stress is simulated and a patterning operation is performed by using a pattern which is deformed in the opposite direction so as to compensate the strain of the mask.
CONSTITUTION: The surface of an X-ray absorber 3 is coated with an electron- beam resist film. A mask pattern incorporating a strain pattern whose phase is opposite to that of a mask-strain estimation value obtained by a simulation is exposed on the electron-beam resist film by means of an electron-beam lithography apparatus. Then, a reactive ion etching operation is performed by making use of the resist film as a mask; the X-ray absorber 3 is patterned. A chip region 8 which has been etched selectively is deformed by a change in the distribution of the internal stress. When the mask of the electron-beam resist film is removed, it is possible to form a mask, for X-ray exposure, in which a selective X-ray transmission region has been formed. At this time, the pattern is deformed in an exposure operation, and the mask can be formed in a desired shape.



LEGAL STATUS
[Date of request for examination]
[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]
[Date of registration]
[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

CLAIMS

[Claim(s)]
[Claim 1] The process which forms an X-ray absorption body membrane (3) on the radioparency film (2), and the process which measures the internal stress committed to said X-ray absorption body membrane (3), The process which simulates distortion of the mask produced by change of stress distribution when patterning of said X-ray absorption body membrane (3) is carried out to predetermined mask shape, The manufacture approach of the mask for X-ray lithography including the process which carries out patterning of said X-ray absorption body membrane (3) by the pattern made to deform into hard flow so that said mask distortion may be compensated.
[Claim 2] The process which measures said internal stress is the manufacture approach of the mask for X-ray lithography including flatness measurement of the front face before and behind said X-ray absorption body membrane (3) formation according to claim 1.
[Claim 3] The process which simulates distortion of said mask is the manufacture approach of the mask for X-ray lithography of claim 1 thru/or 2 publications performed in consideration of the plane configuration and thickness of request mask shape.
[Claim 4] The process which carries out patterning of said X-ray absorption body membrane (3) is the manufacture approach of the mask for X-ray lithography including forming the resist film on an X-ray absorption body membrane (3), laying on a stage the support substrate (1) which supports the radioparency film, and exposing by controlling a stage location to compensate the location fluctuation obtained in simulation according to claim 1 to 3.
[Claim 5] The manufacture approach of the mask for X-ray lithography including the process which carries out patterning of the new X-ray absorption body membrane so that the patterning location of the X-ray absorption body membrane which performed patterning may be measured so that distortion may furthermore be compensated, a difference with a request pattern location may be detected and the difference may also be compensated according to claim 4.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] Especially this invention relates to the manufacture approach of the mask for X-ray lithography including processing of the X-ray absorption body membrane formed on the radioparency film (mask substrate) about the manufacture approach of the mask for X-ray lithography.
[0002] In recent years, with promotion of high-performance-izing of electronic equipment, multi-functionalization, and the formation of small lightweight, the place in which the degree of integration of the VLSI which should also be called the core remains was not known, but it is improving. If an example is taken to DRAM which is the typical device of a VLSI, according to the reduction Ruhr, the degree of integration is increasing by one 4 times the rate of this in 3, and commercial production of 16 M bit DRAM has already been performed.
[0003] At 256 M bit DRAM by which commercial production is scheduled late for the 1990s, memory cell area is 2 10 micrometers. It is predicted that it becomes the following and line breadth is set to 0.3 micrometers or less.
[0004] By contraction of the wiring line breadth accompanying such degree-of-integration increase, the wavelength of the lithography light source which the patterning takes is shifted to a short wavelength side, and it is thought that an X-ray lithography method becomes a subject in the area of increased uptake beyond 256M bit.
[0005] Since there is neither the diffraction in a mask edge being disregarded since wavelength's is as short as several A, nor the proximity effect which is produced in the case of electron beam lithography, high resolution can attain an X-ray easily. 0.1-0.5 micrometers is obtained as the minimum patterning dimension.
[0006] However, since manufacture of the contraction projection optics over an X-ray is difficult, only patterning with an actual size mask can use it. For example, a double mask, such as having the line breadth of 0.1 micrometers - about 0.3 micrometers, is formed in an about [20-50mm square] mask field, and the resist film on Si substrate is exposed by the step-and-repeat method.
[0007] In order that manufacture of an actual size mask may etch the thin X-ray absorption body membrane on the thin radioparency film into an arbitration pattern and may perform it, whenever [technical difficult] is as large as the minuteness of a processing dimension conjointly, therefore mask manufacture serves as key technology of X-ray dew opto-electronics.

[0008]
[Description of the Prior Art] An element metal with the large atomic numbers, such as Ta, and W, Au, is used for the X-ray absorption object which is an X-ray mask ingredient. Since an X-ray lithography mask is formed in the shape of a thin film, the mask substrate (radioparency film) which consists of a radioparency ingredient a little thicker than this mask film as the support plate is used. That is, an X-ray absorption body membrane is processed in the condition of having deposited on the mask substrate.
[0009] SiC, Si, diamond-like carbon, etc. have the small atomic number into a mask substrate

ingredient, X-ray penetrability is high into it, and the comparatively big thing of Young's modulus is used for it. The mask substrate is formed in the shape of a thin film on the need of making X-ray absorption small, in order to make the X-ray which penetrates opening of an X-ray absorption body membrane irradiate on exposure objects, such as resist film on Si wafer. A substrate substrate with this thick mask substrate and usual are made to deposit on Si wafer, and it forms them.

[0010] Then, Si wafer rear-face periphery is fixed to susceptor, etching removes these Si wafers other than a fixed part from a rear face, and a membrane field is formed. A membrane field consists of an X-ray absorption body membrane deposited a mask substrate and on it. After forming a membrane field, patterning of the X-ray absorption body membrane is carried out to request configurations, such as predetermined Rhine and a tooth-space pattern, and the mask for X-ray lithography is obtained.

[0011] When internal stress was working to the X-ray absorption body membrane and an X-ray absorption body membrane is processed into a request pattern, change of stress distribution arises and deformation (distorted) arises in the radioparency film and an X-ray absorption body membrane. For this reason, the pattern obtained will deform.

[0012] For this reason, conventionally, membrane formation conditions and a membrane formation ingredient were chosen, and the laminated structure of an X-ray absorption body membrane / radioparency film (mask substrate) was formed so that the internal stress of an X-ray absorption body membrane might become low as much as possible.

[0013]

[Problem(s) to be Solved by the Invention] However, it is very difficult to negate completely the internal stress of an X-ray absorption body membrane. It becomes the magnitude which cannot disregard distortion to produce if patterning of an X-ray absorption body membrane is performed after etching of Si wafer when the area of a membrane field is large especially.

[0014] Since the pattern of a VLSI repeats and carries out efficiency of the mask process to same Si substrate which should form a device, if distortion is in each mask, a pattern will shift mutually.

[0015] For this reason, high precision patterning cannot be performed but the yield falls sharply. The purpose of this invention is offering the manufacture approach of the mask for X-ray lithography a radioparency pattern with little deformation from a request configuration being obtained.

[0016]

[Means for Solving the Problem] The manufacture approach of the mask for X-ray lithography of this invention includes the process which forms an X-ray absorption body membrane on the radioparency film, the process which measures the internal stress committed to said X-ray absorption body membrane, the process which simulates distortion of the mask produced by change of stress distribution when patterning of said X-ray absorption body membrane is carried out to predetermined mask shape, and the process which carries out patterning of said X-ray absorption body membrane by the pattern made to deform into hard flow so that said mask distortion may be compensated.

[0017]

[Function] By inserting in distortion by the opposite phase in the drawing process of a mask pattern, distortion will be negated substantially and the pattern of the mask which deformed with the internal stress after etching will be obtained in a desired configuration.

[0018] Hereafter, this invention is described in more detail based on an example.

[0019]

[Example] Drawing 1 shows the structure of the mask for X-ray lithography by the example of this invention. A top view is shown in the upper part among drawing, and a sectional view is shown in the lower part.

[0020] First, the radioparency film (mask substrate) 2 which consists of a material which penetrates an X-ray is deposited on the Si wafer 1. The field display flatness (flatness) of the Si wafer 1 is measured in this condition. Since Si wafer will curve convex or convex if tensile stress and compressive stress have arisen in the mask substrate 2, internal stress can be known from

the deformation.
[0021] Then, the X-ray absorption body membrane 3 is deposited on the mask substrate 2, and the field display flatness of the Si wafer 1 is measured again. This result shows the internal stress in the laminating of an X-ray absorption body membrane and a mask substrate. If the measurement data before and behind X-ray absorption body membrane membrane formation is contrasted, the internal stress generated in the X-ray absorption body membrane 3 interior can be known.
[0022] Therefore, change of the internal stress distribution generated when dirty-off of the X-ray absorption body membrane 3 is alternatively carried out at the following process is expected, and the strain distribution (deformation) generated in the X-ray absorption body membrane 3 and the mask substrate 2 under it can be simulated. Therefore, in order to arrange the pattern after deformation in a request location, it is turned out whether what we should do with a variation rate at the beginning.
[0023] Then, the rear-face periphery of the Si wafer 1 is fixed to a housing 4, wet etching removes the field (central field) of Si wafers 1 other than the part in contact with this housing, and the membrane field 7 is formed.
[0024] Next, the electron-beam-resist film is applied to X-ray absorption body membrane 3 front face, and the mask pattern which inserted in the distorted pattern of the mask distorted forecast obtained in the above-mentioned simulation and an opposite phase is exposed on the electron-beam-resist film with electron-beam-lithography equipment. Exposure of the electron-beam-resist film obtains the mask transformed beforehand.
[0025] Subsequently, patterning of the X-ray absorption body membrane 3 is carried out by reactive ion etching (RIE) by using the resist film as a mask. The chip field 8 where selective etching was performed deforms by change of internal stress distribution. If the mask of the electron-beam-resist film 5 is removed, the mask for X-ray lithography in which the alternative radioparency field was formed will be done.
[0026] Here, it can consider as the thing of a request of the mask shape acquired after the selective etching of an X-ray absorption body membrane by transforming the pattern intentionally at the time of exposure (variation rate).
[0027] In addition, when internal stress has a certain amount of distribution or it is hard to expect change of the stress distribution by the selective etching of an X-ray absorption body membrane sufficiently with high precision, it is more desirable to once carry out selective etching of the X-ray absorption body membrane based on simulation, to measure the mask pattern actually obtained as a result, to feed back a result, and to perform selective etching of a new X-ray absorption body membrane again.
[0028] Moreover, if the aspect ratio which removed the deposition thickness of the X-ray absorption body membrane 3 by the patterning width of face (Rhine and tooth-space width of face) of an X-ray mask becomes large, it will become inadequate [just two-dimensional strain distribution prediction].
[0029] That is, by the Rhine-like X-ray electric shielding pattern, the stress of the direction of a right angle is easy to be released in Rhine, and the stress of a direction parallel to Rhine is hard to be released. Since extent of destressing changes with height from a radioparency film surface, three-dimension-analysis is desired.
[0030] It is desirable to simulate the stress distribution in the X-ray mask longitudinal section by making an aspect ratio into a variable in this case, to predict the mask distortion by three-dimension-stress distribution in addition to the stress distribution based on two-dimensional analysis, to search for the strain distribution within a flat surface, to perform mask patterning which inserted in that opposite phase distorted pattern, and to manufacture the mask for X-ray lithography.
[0031] Hereafter, a concrete example is explained more. The mask substrate 2 which is used as a support substrate and which uses a CVD method, for example on the Si wafer 1 with a diameter of 4 inches, and consists of SiC with a thickness of 2.5 micrometers is formed, and the X-ray absorption body membrane 3 which consists of Ta with a thickness of 0.8 micrometers by the spatter on it is deposited. The built-in stress of Ta film is calculated by measuring the

display flatness (flatness) of the Si wafer 1 before and after sputtering.
[0032] Next, distortion (deformation) which will be produced when selective etching of the X-ray absorption body membrane 3 is carried out is simulated based on stress distribution. Drawing 2 (A) shows the strain distribution in the chip field 8 containing the selection pattern predicted by this technique. The direction where the sense of an arrow head is distorted is expressed to magnitude with the distorted magnitude of the arrow head of drawing again. In distorted simulation, the chip field 8 was divided into the small field of 2mm angle, and it asked for the distortion in the central point of each field.
[0033] Next, adhesion immobilization of the rear-face periphery of the Si wafer 1 is carried out at the housing 4 which consists of a ceramic SiC, and the Si wafer 1 is etched from a rear face using ****** mixed liquor. As illustrated to drawing 1 , except for jointing with a housing 4, dirty-off of the Si wafer 1 is carried out by this process, and the thin membrane field 7 is formed of it.
[0034] Next, the mask pattern of the request which inserted the distorted pattern of the distorted forecast which applied the electron-beam-resist film (not shown) and was described above, and an opposite phase into the front face of the X-ray absorption body membrane 3 which consists of Ta is drawn and developed on the electron-beam-resist film with electron-beam-lithography equipment.
[0035] Although it is more exact at this time if the location and configuration of each pattern are amended, the inside of an object side is simply divided into a subsection, and the mask shape in a subsection is left as it is, and should just move only a center position. This can be performed only by adjusting the location of the stage in which a mask is laid in EB exposure.
[0036] While for example, a step-and-repeat method performs EB exposure, distorted amendment can be easily performed by adjusting a stage location. After exposure, the resist film is developed and a resist mask is obtained.
[0037] Thus, reactive ion etching (RIE) performs patterning of the X-ray absorption body membrane 3 by using as a mask the resist film 5 by which patterning was carried out. RIE is performed without heating using the gas of for example, a chlorine system.
[0038] Since the dirty rate of this anisotropy dry etching is large with a metal and it is small at SiC, the mask substrate 2 works as a stopper. The chip field 8 which contains this result, for example, Rhine, and a tooth-space pattern by 0.8-micrometer width of face is formed.
[0039] If the electron-beam-resist film 5 is removed, the mask for X-ray lithography of the structure shown in drawing 1 will be obtained. The example of the resist with a built-in opposite phase distorted pattern formed in the chip field 8 before the selective etching of an X-ray absorption body membrane is shown in drawing 2 (B). In the case of an about [25mm square] chip field, distorted maximum can be set to about 0.2 micrometers or less. It is the 1 field of an electron ray aligner 1mm 2 If it stops below, even if it applies feedback only to a stage by the step-and-repeat method, degradation of the bond precision of each field will be suppressed by 0.02 micrometers or less, and it will be satisfactory practically.
[0040] If selective etching of the lower X-ray absorption body membrane is carried out using the resist mask shown by drawing 2 (B), stress distribution will change and a mask will deform as a whole. As a result of deformation, as shown in drawing 2 (C), the mask for X-ray lithography with which the gap from a desired pattern has very few patterns is obtained. Each smallness field central point is arranged mostly in a desired location.
[0041] If Rhine and tooth-space width of face are shortened and the aspect ratio which is a ratio to the width of face of the thickness of the X-ray absorption body membrane 3 becomes large, it will become inadequate [two-dimensional distorted prediction]. For example, in the case of Rhine width of face of 0.4 micrometers, and an aspect ratio 2, even if it amends using the two-dimensional strain distribution simulated by two-dimensional analysis from the stress measured value before and behind Ta sputtering in the above-mentioned example, a sufficiently high precision is no longer acquired.
[0042] Drawing 3 (A) shows the example of the strain distribution acquired when a radioparency mask is actually formed. A 24mm one-side chip field is divided into one-side a 2mm subsection, and a pin-like segment shows migration of the reference point in each subsection. Contrast of drawing 2 (A) and drawing 3 (A) shows that the error has arisen in the distorted two-dimensional

distribution by the stress distribution which changes with formation of a mask pattern. This can be explained as follows.

[0043] In the mask longitudinal section which cut the big mask of an aspect ratio at right angles to a field, extent of destressing changes with magnitude of an aspect ratio. As for a direction parallel to Rhine, in the case of a Rhine-like X-ray electric shielding mask, stress is hard to be released, but as for a direction perpendicular to Rhine, stress is released easily.

[0044] It is the internal stress of Ta film before etching the strain distribution of the longitudinal section 5.0x108 dyne/cm2 If it simulates as a uniform thing, distribution like drawing 3 (B) will be acquired, for example.

[0045] If the Rhine width of face becomes narrow so that clearly also from drawing 3 (B), a great portion of vertical stress will be released in Rhine. On the other hand, the stress of a direction parallel to Rhine remains. Actually produced distortion can be simulated with high precision by searching for such strain distribution in the longitudinal section according to the pattern which should be formed, and searching for the three-dimension-strain distribution inserted into the strain distribution in the 8th page of a chip field.

[0046] Thus, if the location of a mask pattern is amended by making obtained distortion into an opposite phase and it returns to the stage of electron-beam-lithography equipment, the highly precise mask for X-ray lithography can be manufactured.

[0047] Although Ta was used as a material of the X-ray absorption body membrane 3 in the above-mentioned example, W, Au of the ability of other heavy-metal ingredients to be used, etc. are obvious besides this. Moreover, other ingredients, for example, Si, diamond-like carbon, etc., with Young's modulus high as an ingredient of the mask substrate 2 etc. can be used. Of course, the ingredient of a housing 4 can also be chosen variously.

[0048] Although this invention was explained in accordance with the example above, this invention is not restricted to these. For example, probably, it will be obvious to this contractor for various modification, amelioration, combination, etc. to be possible.

[0049]
[Effect of the Invention] As explained above, according to this invention, the mask for X-ray lithography with a location precision high as a result can be obtained.

[Translation done.]